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FLAME RETARDANT MULTIPLE DENSITY COTTON FLOTE[1] PRODUCTS FOR FURNITURE AND MATTRESSES

by

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Cotton batting's traditional position in cushioning markets continues to be threatened by the encroachment of synthetic foams and fibrous materials. To combat this problem and to strengthen cotton batting's markets in upholstered furniture and in mattresses, new and improved products are being sought under a cooperative research project. The research is a joint undertaking of the Textile Fibers and Byproducts Association, The National Cotton Batting Institute, The National Cottonseed Products Association, The Foundation for Cotton Research and Education, and the United States Department of Agriculture.

Earlier research under this cooperative undertaking resulted in the development of the Cotton Flote process whereby dimensionally stable, highly resilient products can be made in densities from 1.5 to more than 6 pounds per cubic foot. These products resist compaction in use and have tensile strengths as much as 15 times as great as conventional cotton batting.

The process in essence involves the spraying of a combination of both thermoplastic and thermosetting resins onto the cotton fibers while they are openly arrayed in web form. This is followed by conventional lapping, then drying and curing. The process is covered by U. S. Patent 3,181,225, which is in the public domain and, therefore, available for use within the United States on a license-free, royalty-free basis.

In addition, it is possible to produce molded Cotton Flote products that retain enhanced resilience, tensile strength, dimensional stability and integrity as well as resistance to compaction in use. This process is covered by U. S. Patent 3,350,486, which is also in the public domain and available for license within the United States on a royalty-free basis.

The versatility of the Cotton Flote process has been explored further with efforts being concentrated on improving the ability of the products to resist damage by fire, and in the development of products that would be of interest to the manufacturers of furniture and mattresses.

The enactment of the 1967 amendments to the Flammable Fabrics Act 88-1953 will undoubtedly directly affect the manufacturers of furniture and mattresses. Evidence of this is contained in Senate Report 407 of the 90th Congress, First Session on Bill 1003, which defines "Interior Furnishings" as any type of furnishing made in whole or in part of fabric or related material and intended for use or which may reasonably be expected to be used, in homes, offices, or places of assembly. On June 10, 1970, the Department of Commerce which will administer the new law announced that a flammability hazard existed in mattresses and that standards would be needed. In anticipation of this law, research to improve the flame retardancy of Cotton Flote products was initiated in mid-1967. The scope of this research has since been expanded to seek a flame-retardant finish for all cotton batting products concurrent with the development of new products from cotton batting.

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[1] The trade name Cotton Flote is registered by the National Cotton Batting Institute and may be used only by manufacturers who adhere to specified standards of performance for products made under U. S. Patent 3,181,225.

[2] One of the laboratories of the Southern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

An example of the latter aim is to supply a single pad or cushion which would contain as an integral part of its structure (1) either a burlap or cottonet insulator, (2) a dense layer immediately above the insulator to distribute the load on the springs, and (3) a light density topper pad to give the desired amount of "comfort" softness" immediately below the upholstery fabric. Alternatively, several layers of different densities could be fashioned into a single pad in lieu of the high and low density layers described immediately above. Such a product would eliminate much hand labor in faille sewing of the insulator to the pad, and in the assembly of pads of different densities into one composite cushion unit. The concept retained in this research was that the new products must demonstrate integrity, be dimensionally stable, highly resilient, and perform well under a wide variety of environmental conditions. In addition, the products should be in a form that they could be die-cut to a prescribed shape and dimension with sufficiently high tensile strength that they could be handled roughly during the fabrication and use of the article of furniture or mattresses for which it was destined.

That the objectives of the research have been achieved can be seen by the following experimental data.

Experimental

To achieve uniformity in the research products and to closely simulate the type of webs that are produced on a commercial basis, the linters and textile wastes used for the experimental work were converted to a 16 oz./yd. picker lap. This picker lap was fed to a Davis and Furber[3] sample card fitted with garnett type wire. Feed rate was 3.3 to 3.5 oz. per minute. The web produced weighed about 5 oz./sq.yd. As the web exited the garnett, it was passed under a spray nozzle where the selected treating formulation was applied at a rate equal to the weight of the cotton web. The spray damp webs, usually 8 to 10 in number for each formulation used, were then collected on a reel. Where burlap or cottonet insulators were being used they were passed under the spray nozzle and wound on the reel before the spraying of the webs was commenced. These

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3/ The use of a trade name is for purpose of identification only and does not imply endorsement by the U.S. Department of Agriculture of the product named over products of other manufacturers.

insulators had been pretreated for flame retardancy with a formulation whose solids consisted of four parts urea phosphate flame retardant and one part water-soluble acrylic resin. Net chemical add-on after two dips and two nips followed by drying was about 3 percent.

The built-up array was then removed from the reel and fed to a continuous pilot-plant scale drying and curing oven at a speed of 4 ft./min. Drying was carried out at 210° F. in 4 minutes, and curing in an additional 2 minutes at 320°.

In the commercial application, a camelback reciprocating apron continuously deposits the web on a traveling floor apron. As the web is discharged from the reciprocating apron, it is sprayed on both sides with the treating formulation. The spray system, usually of the airless type, includes about seven nozzles for each side of the web. The built-up spray damp webs are condensed by passing through suitable rolls and then conveyed into a drying and curing oven. Because the condensed buildup of spray damp fibers tends to "rise" or expand during drying, they are restrained between parallel conveyors to maintain the preselected density in the finished product. Drying temperatures of 220° to 240°F. and curing temperatures of 310° to 340° are usually used. In both the research and commercial versions of the Cotton Flote process, the basic spray formulations consist of thermoplastic and thermosetting resins, a catalyst, and in most cases a buffer, and an odor suppressant or masking agent. For flame-retardant products, the appropriate chemical is added to the spray formulation.

Products having different densities in different parts of their structure were made possible by (1) varying the concentration of the spray formulation in terms of reactive resin solids, (2) by varying the ratio of thermoplastic to thermosetting resin, (3) by varying the amount of formulation delivered to the web, and (4) by varying the number of webs sprayed with a particular formulation.

For this research work, the reactive resin solids in the treating formulation were varied from 40 to 10 percent by weight in the experimental products to ascertain the effect of increasing resin solids upon the density and other properties of the products. Similarly the ratio of thermoplastic to thermosetting resin was varied to determine the effect of this variable upon the density and performance characteristics of the product.

The most satisfactory thermoplastic resins of those investigated are vinyl acrylate or vinyl acetate, although such thermoplastic resins as vinyl chloride or vinylidene chloride give an enhancement in the flame retardance of the products. Of the thermosetting resins evaluated, methylated methylol melamine or dimethylol dihydroxy ethylene urea give the best performance so far as resilience is concerned and minimized undesirable properties.

Results

Tables 1 and 2 show the effect of changes in formulation on the density of the various plies of the products. In Tables 1 and 2 the following symbols have been used to represent the chemicals evaluated:

Table 1. Effect of Changes in Formulation on Density of Plies A,B,C and D of Samples V and W

Sample	Chemical Composition		Ply *A* Solids Percent	Ply *B* Solids Percent	Ply *C* Solids Percent	Ply *D* Solids Percent
V	Resin	MMM	63	50	40	27
Cross Section	Latex	PVA	27	40	50	63
Ply *A* Ply *B* Ply *C* Ply *D*	Flame Retardant	UP	10	10	10	10
	Total in Spray		20	20	20	25
	Density, Lb/Cu.Ft		*2.0*	*2.5*	*3.1*	*3.3*
W	Resin	MMM	63	—	—	27
Cross Section	Latex	PVC-ACRY	27	—	—	63
Ply *A* Ply *B* Ply *C* Ply *D*	Flame Retardant	UP	10	—	—	10
	Total in Spray		20	20	20	25
	Density, Lb./Cu.Ft.		*2.2*	—	—	*3.3*

Table 2. Effect of Changes in Formulation on Density of Plies A,B and C of Samples X, Y, and Z

Sample	Chemical Composition		Ply *A* Solids Percent	Ply *B* Solids Percent	Ply *C* Solids Percent
X	Resin	MF	70	45	20
Cross Section	Latex	ACRY	20	45	70
Ply *A* Ply *B* Ply *C*	Flame Retardant	UP	10	10	10
	Total in Spray		15	20	25
	Density, Lb/Cu. Ft.		*1.7*	*2.2*	*2.7*
Y	Resin	DMDHEU	60	35	20
	Latex	ACRY	30	0	0
Cross Section	Latex	SBR	0	55	70
Ply *A* Ply *B* Ply *C*	Flame Retardant	UP	10	10	10
	Total in Spray		15	20	25
	Density, Lb./Cu.Ft.		*2.1*	*2.3*	*2.6*
Z	Resin	MMM	70	0	0
	Resin	MUF	0	45	20
Cross Section	Latex	ACRY	20	0	0
Ply *A* Ply *B* Ply *C*	Latex	SBR	0	45	70
	Flame Retardent	BAP	10	10	10
	Total In Spray		15	20	25
	Density, Lb./Cu.Ft.		*2.1*	*2.7*	*3.0*

ACRY = Polyvinyl acrylate
BAP = Borated amido polyphosphate
DMDHEU = Dimethylol dihydroxy ethylene urea
MF = Melamine formaldehyde
MMM = Methylated methylol melamine
MUF = Modified urea formaldehyde
PVA = Polyvinyl acetate
PVC/ACRY = Polyvinyl chloride-acrylate copolymer
SBR = Styrene butadiene
UP = Urea phosphate complex

An increase in the amount of thermoplastic resin used in proportion to the amount of thermosetting resin used usually results in an increase in the density of the particular layer of the product to which this formulation was applied.

Table 3 shows the resilience performance of the samples having multiple plys of different densities. The densities shown in this table are the composite overall density for the finished pad. Note that samples V and Z with four and three plys, respectively, have essentially the same nominal overall composite density. Likewise, samples W and X with two and three plys, respectively, have the same composite density. The composite density for sample Y is somewhat lower than either of the above pairs.

Table 3. Resilience Characteristics of Samples Having Multiple Plies of Different Densities

Performance Characteristics		Sample No. V	W	X	Y	Z	Control
Density, Lb./Cu.Ft.[1]		2.4	2.3	2.3	2.2	2.5	2.3
Recovery from Cyclic Loading 65 Percent R.H.	0 Min.	94.3	90.6	95.0	92.1	95.2	91.5
	2 Min.	95.5	92.2	96.3	93.4	95.2	93.6
	4 Min.	95.5	93.8	96.3	94.7	95.2	93.6
Recovery from Cyclic Loading 100 Percent R.H.	0 Min.	72.7	71.9	67.5	72.4	69.0	72.3
	2 Min.	75.0	75.0	70.0	75.0	71.4	74.5
	4 Min.	76.7	75.0	71.3	75.0	71.4	76.6
Compression, Percent (1.0 Lb./Sq. In. Load)		60.0	62.2	60.0	63.1	56.5	56.9

[1] Composite Density

For comparison, a single density sample is shown as a control. From a resilience standpoint, the multiple ply samples perform equally as well or better than the single density sample. Under compressive load, the behavior of the samples is, however, entirely different. In the single density samples the load is taken up almost uniformly throughout the thickness of the pad. In the multiple densities, the load takeup is distributed inversely to density; that is, the light density topper compresses more easily than the successively denser plys. Upon the removal of the load, the more dense plys tend to recover more rapidly than the topper light density ply. The sum of the recoveries equals or exceeds the recovery of a single density pad.

The difference discernible in the performance of the samples at 100 percent relative humidity is directly attributable to the chemical formulations used, and most particularly to the latex selected. The improvement in performance is related to the effectiveness of the thermoplastic resin in forming a vapor barrier that slows down the moisture absorption-desorption of the fibers without completely inhibiting changes in moisture content.

The resilience performance of samples made to include either burlap or cottonet insulators as an integral part of the structure showed recoveries from compressive loadings at both 65 and 100 percent relative humidity equal to the samples shown in Table 3. The presence of an insulator did make one difference in the performance. It reduced the percent compression under 1.0 lbs./sq. in. load by about 5 percentage points when cottonet was used and by about 8 to 10 percentage points when burlap was used.

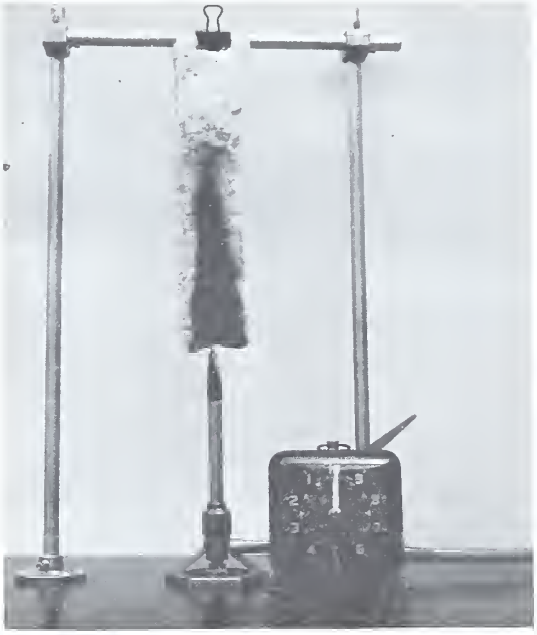

Figure 1
Vertical Flame Test
Modified for Cotton Batting

Figure 1 shows the test procedure used to evaluate the samples for their flame retardance characteristics. The flame is applied to the bottom of the samples for 12 seconds. Time measurements are made for afterflame and afterglow persistence commencing when the Bunsen burner flame is extinguished. The length of the char is measured in two ways. The

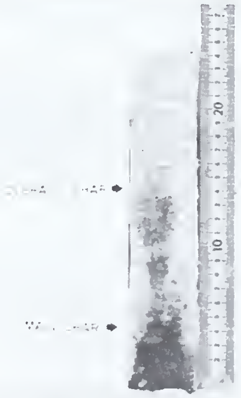

Figure 2
Char Length Measurements

main blackened or charred length from the bottom of the sample is measured in centimeters. The length of the singed or scorched length is measured also in centimeters. The difference between these values gives an indication of the propensity of the samples to flash. None of these samples showed any tendency to flash.

Tables 4 and 5 show the results of the flame retardance characteristics of the samples whose chemical makeup were shown in Tables 1 and 2 and whose physical properties were shown in Table 3. Flame resistance tests were carried out on the samples after they had been exposed to a number of different environmental conditions in accordance with General Motors Corp. (Fisher Body Division) Engineering Section Test Method 30-27 as revised November 13, 1967.

Table 4. Flame Resistance Performance of Samples Having Multiple Plies of Different Densities

			Sample No.			
Performance Characteristics	V	W	X	Y	Z	Control
Conditioned 70 F.° 65% R.H.:						
After Flame, Sec.	0	0.5	0	0	0	0
After Glow, Sec.	0	2.0	0	0	0	0
Overall Char, Cm.	8.0	11.5	14.0	13.0	6.5	5.7
Main Char, Cm.	1.0	3.0	3.0	1.5	1.0	3.5
Soaked With H_2O, Dried 158° F.:						
After Flame, Sec.	0	0.5	0	0	0	0
After Glow, Sec.	0	6.0	0	0	0	0
Overall Char, Cm.	12.0	11.0	9.0	4.5	4.0	4.0
Main Char, Cm.	1.0	3.5	1.5	1.5	1.5	2.0

Table 5. Flame Resistance Performance of Samples Having Multiple Plies of Different Densities

			Sample No.			
Performance Characteristics	V	W	X	Y	Z	Control
100 Percent R.H., 3 Days, 100° F.:						
After Flame, Sec.	0	1.0	0	0	0	0
After Glow, Sec.	0	2.0	0	0	0	0
Overall Char, Cm.	8.0	7.5	7.0	10.0	1.5	3.0
Main Char, Cm.	1.0	3.5	1.0	1.0	0.5	1.0
158° F., 16 Hours.						
After Flame, Sec.	0	0.5	0	0	0	0
After Glow, Sec.	0	3.5	0	0	0	0
Overall Char, Cm.	12.0	11.0	7.5	11.0	8.0	4.0
Main Char, Cm.	1.0	3.0	1.5	2.0	1.0	1.0

After conditioning for 24 hours at 70° ± 2° F. and 65 ± 2 percent relative humidity (Table 4), all of the multiple ply Cotton Flote products had overall char lengths of much less than the 15.25 centimeters permitted by the General Motors test. Only one of the experimental samples (Sample W) showed any afterflame or afterglow under any of the test conditions. Even this sample would, however, be acceptable under the limits set by the test method. The flame retardance probably could be improved by increasing the urea phosphate flame retardant to 12.5 percent of the total solids with a corresponding decrease in the polyvinyl chloride-acrylate latex content of the formulation. All of the samples showed less main char and less overall char than is required to meet the test requirements.

The products would, therefore, be acceptable for use in products designated as containing flame-retardant cushioning materials.

In the series of samples where cottonet or burlap insulator pretreated for flame retardancy was built into the structure as an integral part of the product, the resistance to burning was equal to the performance of samples shown in Tables

4 and 5. None of these samples had any afterflame or afterglow, and char lengths, both main and overall, were essentially equal to those of samples without the insulator. Products made by this technique would also be acceptable for use in products described as flame retardant.

CONCLUSIONS

There are no guidelines at this time that would indicate what degree of flame retardancy might be required for mattresses and furniture once the Flammable Textiles Act is implemented. The impact of the new law, however, will undoubtedly be felt throughout the cotton batting industry. For Cotton Flote there is every reason to believe that products capable of meeting foreseeable requirements can be produced today on a commercial basis. From a wide variety of formulations that incorporate any of a number of flame retardants, it is now possible to produce Cotton Flote products. Flame retardants that appear to be especially suitable include urea phosphates, antimony trioxide, diammonium phosphate plus borax, borated amido polyphosphate, and borated urea formaldehyde. These can be used with vinyl chloride or vinylidene chloride to synergistically enhance flame retardance in the finished products.

The presence of the flame-retardant component in the treating formulation, provided it is properly chosen, seems to have no adverse effect upon the pot life of the formulation.

The chemical add-on of flame retardant to be effective falls between 3 and 8 percent by weight of the cotton fibers treated.

The treated products retain their ability to resist burning after being subjected to (1) mild leaching, (2) 100 percent relative humidity at 100° for 3 days, (3) 158° F. for 16 hours. Cotton Flote products in the form of a pad made up of two or more plys of different densities are possible by a number of variations in the formulations used and by minor changes in the spraying procedure. A preselected number of webs can be sprayed with an elected formulation designed to give a dense pad. A different formulation then can be used on another preselected number of webs. Two, three, four, or more different spray formulations can be used to prepare products having two, three, four, or more different densities. The location of the most dense layer can be selected at will to achieve the amount of "comfort softness or hardness" desired.

The ratio of thermoplastic to thermosetting resin used directly affects the density of the products. Increasing the amount of thermoplastic resin in relation to the amount of thermosetting resin usually results in an increase in the density of the particular layer of the product in which such formulations were used.

Flame retardant cottonet or burlap can be incorporated into a Cotton Flote structure by feeding either of these materials onto the floor apron of the garnett line and spraying the insulator with the formulation to be used for the ply of Cotton Flote to be placed upon it. The manufacturing procedure thence forward is the same as in the normal Cotton Flote system.

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